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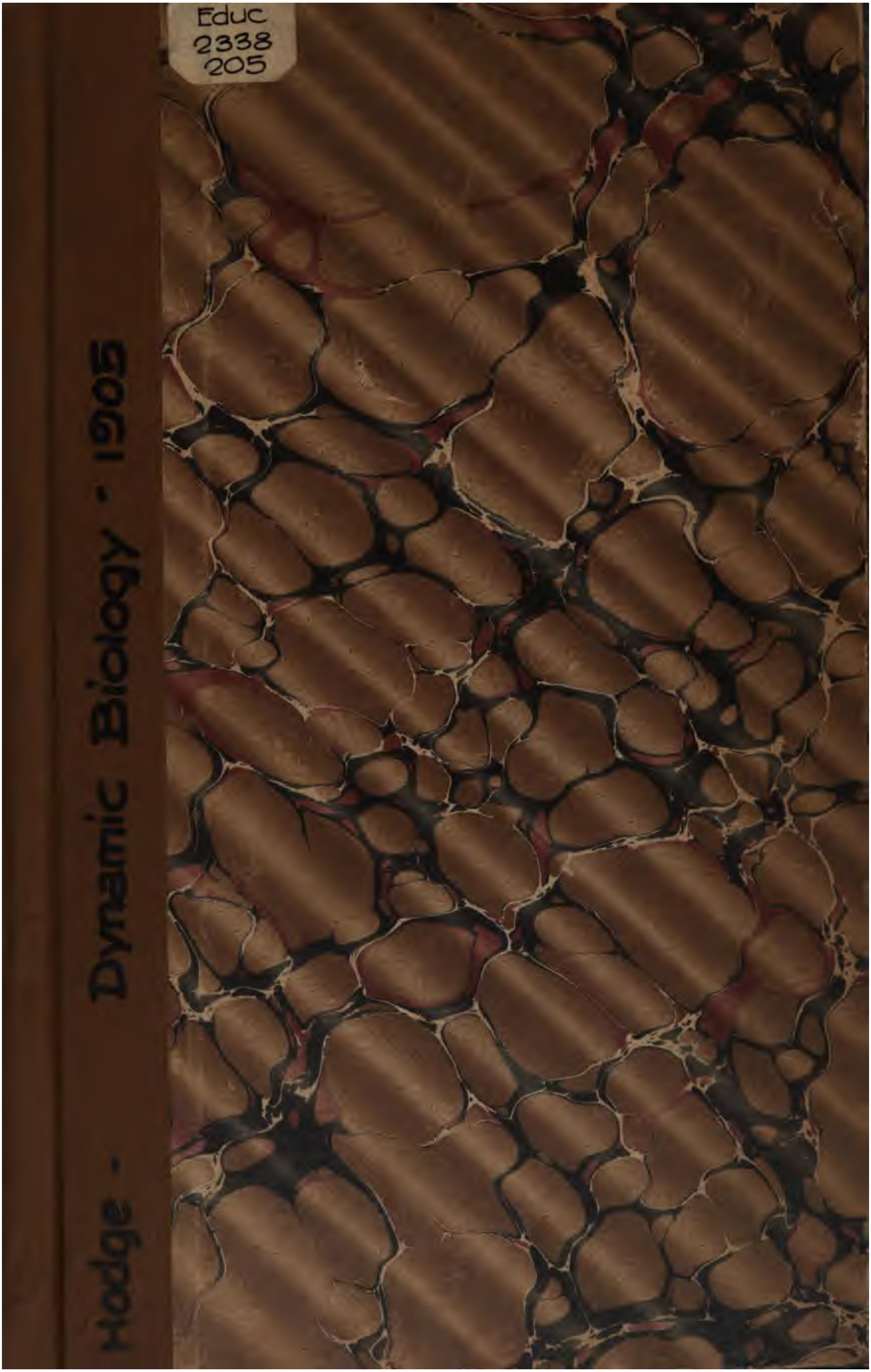

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C. F. Hodge

Dynamic Biology and its Relations to High School Courses

I

Dynamic Biology in the College

II

BY

C. F. HODGE

Reprinted from the PEDAGOGICAL SEMINARY
September, 1904, and June, 1905
Vol. 11, pp. 381-404; Vol. 12, pp. 141-157

DYNAMIC BIOLOGY AND ITS RELATIONS TO HIGH-SCHOOL COURSES.

By C. F. HODGE, Clark University.

I.

Every living organism represents a certain force, does a certain amount of work in the economy of nature. Multiply this work by the number of individuals and we have an expression for the power of the species as a whole. This point of view is definitely expressed in our title. We already have "dynamic geology," "dynamic astronomy," "thermo and electro dynamics," "dynamo" and "dynamite;" and when we begin to realize the forces of living nature, we are fully warranted in applying the term "dynamic" to biology.

With due respect to current methods of teaching, it has often seemed to me—and I find this reaction quite general among biologogical students—that when we were fairly ready to begin the study of a type, we were hurried on to the study of something else, and so on; ever reaching out after knowledge, but never attaining to wisdom. May not this feeling of insufficiency, the haunting question "*cui bono*"? be accounted for in part, at least, by the fact that the largest values both scientific and human centre about what living organisms do? Then, again, when we look toward the future of the science, what large field except this remains to be broken? We have land and sea explored and certainly enough species described to begin with, and form and structure has been worked out almost to the limits of microscopic vision. Surely refined biometry of the dead form cannot rival in importance scaling the total energy output of species alive and at work.

May we not find here also an explanation for the general relation of the public to things biological in the fact that our college and university courses have become too static, too exclusively engrossed with the dead type form? I have tested popular interest in many ways, and any one may do this for himself. Ask the average man: How many birds, insects, fishes or reptiles do you know? Or to be more specific, ask the people of your acquaintance or with whom you walk whether they are acquainted with this plant or tree, bird or insect. We know what the answer will be; or if, perchance, we get some faint echoes of a college or high school course, it will be: "Yes, we did study a little anatomy of the frog, earthworm and grasshopper, but thank the Lord I have forgotten it all."

Or, go into the bookstore in a town or small city—not a college town, of course—and ask for a zoölogy. You will have to explain that you want a book about animals, and then the shopkeeper will look at you as though he had no idea of your meaning and tell you he has no call for books in that line. On one occasion an old man did bring down from an upper shelf an antedeluvian volume—"Animals of Myth and Legend;" and another trotted out with great alacrity, as though he had found a purchaser at last, "Wild Animals I have Known." This, as a result of perhaps thirty trials in several different States, may be taken to represent the relation of the people in general to the life about them. People know, and what is worse, care nothing about it.

I am inclined to attribute this condition to the kind of biology taught in our colleges and universities; and this has sifted down through college educated teachers into normal schools and high schools, until now even in the grades—up to within a year or two, at least—the dead, type-form, anatomical method of study holds the field. Some eminent teacher, Agassiz or Huxley, of a former generation, selected a certain animal as a type, and, because its anatomy was then unknown, he worked it out and taught it in a manner to him living and vital, because closely related to his own investigations. Is this any reason why at the present time, with hundreds and thousands of forms alive and at work everywhere, we teachers, like sheep jumping over a fence, must get the identical animal—probably pickled in alcohol—and must attempt to teach it in the way adapted to the needs of a generation or more ago? Why, as Schmeil so well puts it, should teachers of biology build in the minds of their pupils either air castles or moss-covered ruins?

Practically up to the present the questions put to living things have been: What are you? What is your name? How are you formed and what are your relations? Where did you come from?

The moment we put the question: What do you do in the economy of nature? What are the laws and conditions of your active life? We find ourselves with the most familiar forms, and, whichever way we turn, on the brink of human knowledge. This in itself is inspiring; but when we begin to realize the magnitude of the forces which living species wield and the intricacy and delicacy of their manner and conditions of action, we find that we have entered a field that will return to patient cultivation harvests of untold value for centuries to come. Indeed, when we ask: What is the ultimate value of classification and all the comparative form-study on which it depends? it seems difficult to answer, unless we say that all such knowledge, so far as it is sound, may serve as a foundation from which to investigate the forces of living nature with a view to understand the laws of their action and to discover means to utilize and control them.

The physicists and chemists have outstripped the biologists and in general have given to the courses in these subjects a dignity and a position in our schools which biology lacks. And they have done this in the main by developing practical knowledge of the forces of inanimate nature; while, biologically, we have been content to remain behind in the age of the ox-cart as concerns any serious effort to learn and to teach the magnificent forces of living nature.

It is suggestive in this connection to recall the fact that the fundamental and primitive relations of mankind to living nature have been formed mainly on the dynamic side. Domestication of animals and cultivation of plants is dynamic biology in the rough. It is thus, in a way, the tap root of biological science. Since my attention has been called to this point, I have been surprised to note how often young children, on finding some animal or plant that is new to them, ask: "What can this thing do?" or "What will this do to you?" "Is this good to eat?" "Is this poison?" and so on. A little later, of course, as language develops, the first question comes to be: "What is it?" And while this is commonly assumed to be the first reaction of the knowing mind to its environment, since reality and experience are deeper than language, and the emotions and will, than intellect, may we not have here a more fundamental relation than is generally recognized? Then, further, if the child finds that the animal or plant possesses some power for good or ill he will wish to learn more about it.

Modern developments of this primitive phase are seen in the work of the Department of Agriculture and the United States Fish Commission. But while this marks a great advance in some respects over the efforts of earlier races, it is still, so far as scientific character goes, dynamic biology in the rough. After expenditure of millions of dollars and all these years of puttering and fumbling, we still lack any adequate expression for the value, either biological or economic, of a single species of bird, amphibian or reptile, and of few, if any, fungi or insects. With bulletins galore on the value of the different birds from the Department at Washington and the various State Experiment Stations, and filled with abundant advice as to means of increasing and protecting them, I have yet to see either in Washington or in any of the States I have visited any special provision for birds or other insectivorous animals. On the one hand we have in print the most emphatic denunciation of the

English sparrow and recommendations for its destruction. In reality I have never failed to find English sparrows the most numerous bird about the Agricultural Department grounds in Washington or on the station grounds in the different States. Cats are known to be the worst enemies of insectivorous birds, and I have reports from private farms on which their extermination was followed by a remarkable increase of birds, but I have yet to learn of an agricultural college or experiment station where they are not kept in numbers and allowed to prowl at will. On the one hand we have Koebele's splendid achievement in the introduction of the Vedalia to control the cottony-cushion scale, on the other, the failure of the Massachusetts Legislature to accept his offer to import the natural enemy of the gypsy moth. On the one side are Forbush's and Kirkland's studies with birds and toads in destruction of gypsy moths, on the other, no serious attempt in the infested districts to develop and utilize the living forces discovered. With the light breaking the dawn is slow, and practical biology remains a good deal of a muddle. To dispel the fog, clear the air, and vivify and render the whole subject consistent we need a well developed science of the forces of living nature.

An interesting sidelight is shed on our subject by many of the nature worships and superstitions. These probably developed later than the primitive relations just alluded to, and they again show, however distorted and magnified, man's deeper sense of the overwhelming powers of life. Plagues and pestilences and diseases were looked upon as divine visitations, and in the sense that the laws of nature are the laws of God, ancient interpretations were not so wide of the mark. Ignorance of laws yields no exemption from penalties, and these calamities are now generally recognized to be purely biological phenomena, forces of living nature operating under definite and discoverable laws.

In fact evolution in its various forms is dynamic biology. All the theories which maintain that living forms are rigid, immutable, predetermined, in brief, all the fatalistic theories of life, may be grouped for convenience under the term static biology. Of course, the two are seldom seen in their purity. The static or fatalistic philosophy naturally came first, and dynamic elements are mingled with it throughout, but these natural forces it weakly acknowledges to be too vast for human influence or control. So, too, evolution or the dynamic philosophy, while it blossomed in Lamark and Darwin, had its roots back among the Greeks, and still has tenacious fibers projected into it from the older static thought. Still, the terms, static and dynamic may be conveniently taken to represent the two poles about which all philosophies of life tend to group themselves. It must also be remembered that these two attitudes toward life in general are expressions purely of human faith and have no outward warrant or reality in nature itself. Thus naturally in the early times of human weakness and ignorance the forces of nature seemed irresistible and a static, fatalistic philosophy was the logical result. Later, as knowledge grew by patient research, and the forces of nature were found to be amenable to knowledge and control, evolution and a dynamic philosophy of life broke through the crust of human thought, and the slow process, which had so long been carried on by the few braver souls who had faith in nature, has at last begun openly to contest the field. While thus a matter largely of temperament and majority, some always choosing the static and others the dynamic philosophy of life, and many vascillating in their choices, since men are reasonable and tend to form their judgments on the basis of what they know, it becomes at bottom a matter of education. Whether we have the static-fatalistic or the dynamic-progressive theories of life predominant will thus depend upon the kind of biological education we develop.

I take it that fatalism in all its various forms is the logical consequence of a static theory of life; and this in turn arises from an inadequate or faulty education in regard to means of controlling the forces of life. Thus the sense of weakness and inadequacy crystallizes into a rigid philosophy. It is the theory that nature is too heavy to lift, that the world will wag as it always has, no matter what we try to do about it. This philosophy of life finds its classical expression in the familiar words of Solomon:

"Vanity of vanities, saith the preacher, vanity of vanities; all is vanity. What profit hath a man of all the labor which he taketh under the sun? One generation passeth away and another generation cometh! but the earth abideth forever. The sun also ariseth, and the sun goeth down, and hasteth to the place whence he arose. The wind goeth toward the south, and turneth about unto the north; it whirleth about continually, and the wind returneth again according to his circuits. All the rivers run into the sea; yet the sea is not full; unto the place whence the rivers come, thither they return again. All things are full of labor; man cannot utter it; the eye is not satisfied with seeing, nor the ear filled with hearing. The thing that hath been, it is that which shall be; and that which is done is that which shall be done; and there is no new thing under the sun. . . . I have seen all the works that are done under the sun; and, behold, all is vanity and vexation of spirit. That which is crooked cannot be made straight; and that which is wanting cannot be numbered. . . . For in much wisdom is much grief: and he that increaseth knowledge increaseth sorrow. . . . Therefore I hated life; because the work which is wrought under the sun is grievous unto me: for all is vanity and vexation of spirit."

This is a cheerful view of life, is it not? Everything goes round and round in an idiotic circle. It is no use to do anything, because some one else has done the same thing before. The more we learn, the more we want to know, hence the worse we are off. Things are as they always have been and forever shall be. We may as well hate life and be done with it.

But from this slough of despond it is our good fortune to be set free.

"A boundless hope has crossed the world," and the essence of this hope is to be found in the biological doctrine of evolution. This doctrine has been much abused, misrepresented and misunderstood, but it means at bottom simply that there is progress, a movement from low toward higher in the life of the world; that life does not run round in the idiotic circle with "vanity of vanities and vexation of spirit" as the end result. John Tyler states the argument in the following pointed manner.

"Was there ever a nation of grander promise than Greece or Rome? But Greece died of premature old age, and Rome of rottenness begotten of sin. But each of them, you will say, left a priceless heritage to the immortal race. But if Greece and Rome and a host of older nations, of which history has often forgotten the very name, have failed and died, can anything but utter failure await the race? Is human history to prove a story told by an idiot, or does it 'signify' something? Is the great march of humanity, which Carlyle so vividly depicts, 'from the inane to the inane, or from God to God?' "

"This is the sphinx question put to every thinking man, and on his answer hangs his life. For according to that answer, he will either flinch and turn back, or expend every drop of blood and grain of power in urging on the march."

This faith in progress is the dynamic as distinguished from the static, imbecile, *laissez faire*, fatalistic philosophy of life. What can we need more than this faith in our educational system? Evolution is beginning to mean something. If all nature is struggling up from lower toward higher forms, what are we here for? We are here to work with the rest of nature for progress. Evolution means that the world is growing better, that every effort in the right direction helps to make the world better, that with all—or as many as we can win over to this way of thinking—working together the world will move toward the good faster than it has under the doctrine that life is vanity of vanities. New things have appeared and will continue to appear under the sun as discoveries are made. Paradise will be regained by intelligent and unified human effort—a thing infinitely better than having paradise thrust upon the world from heaven. Under the old philosophy man whined because he was not permitted to lie in the shade and have the forces of nature make the world a paradise for him. Under the new philosophy he sets to work to control the forces of nature, thankful for the mental and physical exercise which keeps him awake and alive.

Evolution is wider in its applications than the science of biology. Besides reaching back into astronomy and geology it lies especially close to historical and sociological studies. This is true, since the life of mankind is but a part of the larger life of the world, and the laws of the life of human history are deeply rooted in the history of all life. As John Fisk says:

"If I may cite my own experience, it was largely the absorbing and overmastering passion for the study of history that first led me to study evolution in order to obtain a correct method. When one has frequent occasion to refer to the political and social progress of the human race, one likes to know what he is talking about.

"Now what does all this drift of scientific opinion during more than two centuries mean? It can of course have but one meaning. It means that the world IS in a process of development, and that gradually, as advancing knowledge has enabled us to take a sufficiently wide view of the world, we have come to see that it is so. The old statical conception of a world created all at once in its present shape was the result of very narrow experience; it was entertained only when we knew an extremely small segment of the world. Now that our experience has widened, it is outgrown and set aside forever; it is replaced by the dynamical conception of a world in a perpetual process of evolution from one state into another. The dynamical conception has come to stay with us. Our theories as to what the process of evolution is may be more or less wrong and are confessedly tentative, as scientific theories should be. But the dynamical conception, which is not the work of one man, be he Darwin or Spencer, or any one else, but the result of the cumulative experience of the last two centuries—this is a permanent acquisition. We can no more revert to the statical conception than we can turn back the sun in his course. Whatever else the philosophy of future generations may be, it must be some kind of a philosophy of evolution." (Century of Science, pp. 42 ff.)

Human history thus is in part dynamic biology and since man is the great moulding and controlling factor, we must never lose sight of human relations to nature in all our biological education. On the older view, the most despairing; under the newer ideal, the most inspiring fact of all human history is the origin, growth, florescence, maturity, and then the senescence, decay and dissolution of all the great civilizations. Whole animal and plant species have run the same cycle, have arisen, flourished, dominated the life of the world for a time and then died out under altered conditions or stress of competition with other species. This is also for most animals and plants the normal cycle of life for the individual. It would require a separate paper, much too theoretical for our present limitations, to even outline the biological factors involved and their relations to the human problem. It is sufficient for our present purpose to say that not all organisms follow the cycle just described. Forms with great plasticity, notably among the microscopic animals and plants, seem to be practically eternal, or, at least, able to maintain their adjustments to our present order of nature for indefinite periods. This power seems also to inhere in the germ cells of higher animals and plants. It is only as life becomes rigid, static, unable to adjust itself to new conditions that the law of senescence comes into play.

It has been remarked that religion rocks the cradle, while philosophy bends over the grave of every civilization. There is still another muse—Science. Is it beyond the bounds of possibility that somewhere in the universe of truth there may be a "fountain of eternal youth" for a human social order, and that by diligent research She may discover it? Is it not possible that by knowing enough of the laws, the forces and the resources of life, a civilization may endure and continue to grow into ever stronger and fuller life?

Evolution gives us no uncertain answers to this momentous question. If life in the world has worked and struggled up from the lowest microscopic forms to man as we know him; what can prevent its reaching up to ever higher and higher types of men? We may refer in this connection to John Fisk's "Destiny of Man," or Drummond's "Ascent of Man." In fact, recent biological literature is beginning to tingle with the new life of this idea. In his technical treatise on physiological chemistry Bunge states the argument in a word as follows:

"Do not misunderstand me to say that I recognize any barrier as insurmountable to Science. No, Science is daunted by no self erected barriers. Science will ask ever bolder questions and find ever truer answers. Nothing can arrest her in her victorious march. Even the limitations of the human mind cannot do this: for even these may be perfected. There is not the slightest reason to believe that a continuous development toward higher forms which moves the entire organic life on our planet has reached its goal in this our generation. The time was, when the only sentient beings upon the earth were microscopic infusoria whirling about in a primordial ocean; and the time will be, when this earth shall be ruled by a race of men that shall rise as much superior to us in intelligence as we are superior to the amœba. The progress of science is infinite."

Whether this shall apply to our civilization must depend largely upon the kind of biological wisdom we develop. And the kind of biology that is woven into the warp of modern life must in large measure depend upon the courses which we succeed in weaving into our educational system.

I recently had the good fortune to discuss the present situation at length with Professor Whitman; and he said emphatically that our biological courses had fallen into a state of "*dry rot.*" What with microscopes and microtomes, skeletons, museums and dissecting instruments usurping the whole field, life itself with all its power and movement is being crowded out of our so called biological courses. Why is this so, and how is it possible for such an incongruous condition of affairs to occur—laboratories for the study of life so completely engrossed in mere dead form? It is, of course, much easier to study and to teach dead form than living activities. When men get sedentary, they are apt to become physically weak; and then there is an almost irresistible undertow toward a static philosophy of life. Of course these teachers bring together a series of type forms that present a spectral parade of the living evolutionary process. But who is interested in ghost dances? Why not have the real thing? As an object of abstract thought the spectral series of type forms has its uses, but, it seems to me, that such pure abstractions which have no relations to the life of the community belong back in the dark ages—to the ages of dreams and nightmares, before humanity had waked up—to the age of dull scholasticism and metaphysics, when men spent their time disputing about how many angels could dance on the point of a cambric needle. Man is now the all important factor in organic evolution, and where does he come into the scheme? Our type-form biologists will soon have stuffed specimens of him to stand at the head of their series in the museums. The way we have lapsed into static biology is enough to make Darwin turn in his grave in Westminster Abby.

Every living organism represents a certain force, does a certain amount of work. Determine this with the greatest care for the individual and multiply by the number of individuals of the species and we gain an expression for the power of a species as a whole. We learn the species, not merely as a dead form, but as a force in nature. And further, study all species of animals and plants from this point of view—or for practical courses, select dynamic types—and we develop a picture of nature as a vast stream of living forces acting and reacting upon one another, a picture of nature as it lives, moves and has its being; and we gain a view of the dynamic process of organic evolution.

If we may grant, at least provisionally, that it is desirable to put a thorough going dynamic biology into our educational system: How shall we accomplish it? What lines are fundamental? How shall we choose subject matter? How shall we stratify the subject for educational grades—for the grammar and high schools, the college and the university?

When the problem first formulated itself in my mind—about seven years ago—I answered without hesitation: make the latest and best results; the strongest and largest ideas, generally available. Do away once for all with the prevailing notion: "the world owes me a living," and by teaching the struggle for life and natural selection, establish, presto, in the public mind the stern fact that the world may owe a hanging instead, and so displace the old with the new ideal—basally true to all nature and to the organization of society as well—that the first duty of each man is to make himself fit to survive. Copious lecture notes and manuscripts were produced —I now thank my lucky star that none of them were printed—during this balloon voyage among the clouds of educational theory; but the air was thin and chilly, and I was lonesome. Many of the younger German educators are just now in high chase after this brilliant, educational meteor, but I doubt if they catch it until it reaches the earth, and by that time they may realize that the earth is larger than the meteor. So is human sympathy and love of nature larger than any science or any pet theory of education; and the forces of living nature with their infinite complexity and adjustments and their discovered and undiscovered relations to human life and happiness reach out in every direction far beyond our formulated theories of organic evolution. So I awakened from my dream of doctrinal evolution in the grammar schools to the realization that we must have first a broad basis of general knowledge and acquaintance with nature; that thousands of years of struggle and conquest and hate and love of nature preceded our modern formulations; that Darwin himself as a mature and learned man incubated his great idea for twenty years and then was hastened into trusting it with the public.

I have endeavored to formulate my own creed with reference to this deepest stratum of biological education in three articles which appeared in this *Journal*[1] and in my book, Nature Study and life.[2] This stratum is the vital part of our entire system of education as relates to the establishment of a philosophy of life. It is the bed rock upon which we must build. With this reference, then, we may go on to consider the strata adapted to high school instruction.

Research, as we ascend the scale, becomes more and more essential. In fact, research is the breath of mental life, whereas memory is merely the bodily form of education. It is the human side of the process of evolution. Nature's challenge to man has ever been: find me out, and I will be your friend and servant. If you do not, I will destroy you. To live in dependence upon authority is nothing short of parasitism. It is easier than to live by research and so systems of authority are developed which save men the trouble of living and lead them around in the circles of vanity. Like water, which can never rise above its source, all such systems tend to become stagnant and prevent rather than encourage progress. It has always seemed to me that in originality the spirit of the child is ideal and that to keep it fresh and alive throughout the necessary drudgery of elementary schooling is the special function of nature study.

Nothing can illuminate this point like a glimpse over the historical development of biological science. For tangible beginnings, at least, we must go back to Aristotle and the Greeks—about 2200 years. A science must first collect its facts and sift them from prejudice, superstition and fanciful imaginings. Aristotle, the friend of Phillip and teacher of Alexander the Great, has been called the best observer the world has produced. He is said to have had the assistance of their armies in collecting specimens for his researches, and his works on the History of Animals and on the Parts of Animals contain a mine of wonderful richness. It is remarkable how many of our nature saws we owe to Aristotle. Here are a few samples of the kind of biology that Alexander the Great was brought up on.

"The part of the head by which we hear, but do not breathe, is the ear; for Alcmaeon is mistaken when he says that goats breath through their ears. Man is the only animal that has ears and cannot move them."

"Observations have been frequently made on the instinct ot the hedgehog, for when the north and south winds change, those that dwell in the earth alter the position of the entrance of their burrows; those which are kept in houses alter their position from wall to wall, so that they say that in Byzantium there was a person who obtained the character of predicting the change of the weather, from observations made on the hedgehog."

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[1] Foundations of Nature Study. *Ped. Sem.*, Vols. VI and VII.

[2] Nature Study and Life, Ginn & Co., 1902.

"The swan also is web-footed, and lives in ponds and marshes. Its manner of life and disposition is good, and so is its manner of rearing the young and its old age. If an eagle attacks the swan, it defends itself and comes off victorious, but will not commence the fight. Swans have the power of song, especially when near the end of their life; for they then fly out to sea, and some persons, sailing near the coast of Libya, have met many of them in the sea singing a mournful song, and have afterwards seen some of them die."

"The most laborious of all insects, if compared with the rest, are the tribes of the ants and bees. Every one may see the diligence of the ant; for it is on the surface, and that they always travel in one direction, and make a store and treasure-house of food, for they work even in the night when there is a full moon."

"Butterflies are produced from caterpillars, and these originate in the leaves of green plants. At first they are smaller than millet, afterwards they grow into little worms, in three days they become small caterpillars, afterwards they grow and become motionless and change their form. In this state the creature is called a chrysalis. It has a hard covering, but moves when it is touched. They are united to something by web-like processes, and have no mouth nor any other visible organ. After a short time the covering is burst, and a winged animal escapes, which is called a butterfly." Of a certain caterpillar Aristotle says: "From this animal some women unroll and separate the cocoons and afterwards weave them. It is said that this was first woven in the Island of Cos by Pamphilla the daughter of Plateos."

From a study of his works we see that Aristotle was a tireless investigator, fearless in questioning authority, careful and accurate in observation far beyond his time, and still his method is not rigidly scientific, and he is often led into romancing by plausible hearsay and many of his interpretations are vitiated by preconceived notions of the fitness of things. We are especially struck with the living dynamism that permeates all his biological work. He studies the parts of animals to discover their functions, and animals themselves largely to gain a knowledge of their uses to man and their various activities. Thus despite its shortcomings Aristotle's work had the virility to dominate science for nearly two thousand years. All through later Grecian and Roman times and up through the middle ages his word was law, to doubt which was heresy. Research was no longer necessary. To find out the truth, simply read the book and learn what Aristotle said about it. If facts did not agree with the book, then facts must be wrong. If we substitute the dead letter of authority for the living spirit of research, we have mental stagnation and death; and all dead things, whether human minds or oak trees, tend only toward disintegration and decay. So the science of biology lapsed into decadence for two thousand years after Aristotle.

Dropping down about four hundred years we may take a sample or two of Pliny's biology.

"Some persons," he says, "recommend that three crabs should be burned alive among the trees on which the vines are trained, to prevent these from being attacked by coal blight." Also that, "If a bramble frog is buried in a new earthen vessel in the middle of a cornfield, there will be no storms to cause injury."

Fish stories are notorious, and here is a little one of Pliny's:

"In the city of Iasus there was another boy, also Hermias by name, who in like manner used to traverse the sea on a dolphin's back, but on one occasion a tempest suddenly arising, he lost his life, and was brought back dead; upon which the dolphin, who thus admitted that he had been the cause of his death, would not return to the sea, but lay down upon the dry land, and there expired."

Pliny's human anatomy is no less wonderful. He tells us of a race of savage men whose feet are turned backwards relatively to their legs. He also describes another race of men, "who are known as Monocoli, who have only one leg, but are able to leap with surprising agility. The same people are also called the Sciapodae, because they are in the habit of lying on their backs during the time of extreme heat, and protect themselves from the sun by the shade of their feet." "These people," he says, "dwell not far from the Troglodytae, to the west of whom again there are a tribe who are without necks, and have their eyes in their shoulders."

Pliny, it is said, was paid enormous sums for his books. He represents the kind of natural history the Romans wanted. Among people who have no regard for truth there can be no conception of its value; and hence it is not the man who can discover and tell them the most truth, but the man who can tell the biggest stories who is in demand. The craving for the "wonderful" is deeply rooted in human nature, and we have just now, possibly, a recrudescence in what John Burroughs calls "Sham Natural History," and, as in the times of the Romans, the books sell better than almost any others. Still, as truth is stranger than fiction, I am inclined to think that any help we need will come from displacing the "sham" with a truer and more living natural history rather than by futile controversy.

Coming down now sixteen hundred years we may take another sample of biological teaching. This is nothing less than a receipt for raising snakes by the most learned and illustrious Jesuit physician and naturalist, Athanasius Kircher.

"Take some snakes," he says, "of whatever kind you want, roast them and cut them into small pieces and sow those pieces in an oleaginous soil; then, from day to day, sprinkle them lightly with water from a watering pot, taking care that the piece of ground be exposed to the spring sun, and in eight days you will see the earth strewed with little worms, which, being nourished with milk, diluted with water, will gradually increase in size till they take the form of perfect serpents." He adds that he learned all this from once having observed in the country "the carcase of a snake covered with worms, some small, others larger, and others, again, that had evidently taken the form of serpents."

Possibly Kircher thought he was safe in writing this, because no one would ever wish to raise snakes, but he was mistaken. An Italian naturalist, Redi by name, did want to raise snakes and tried it again and again. By this method, however, he did not succeed in rearing "a single blessed snakelet;" but, instead, generation after generation of flies. He found their eggs and watched them hatch and develop from maggots into winged insects and wrote his epoch-making book, De Generatione Insectorum. Thus grafted into an ancient root of error original research has brought forth the new science of life whose fruits we are beginning to enjoy.

This excursion into biological history will not have been in vain, if it serves to make clearer two points. Men must learn to tell the truth and in order to do this must know how to discover the truth before we can have any science. Mental life is nourished and grows strong by feeding upon the truth of nature as physical life is sustained by food. There can be no lasting substitutes for food or truth. If fanciful error, however intoxicating, is rated as good or better than truth of nature, then all science and all sound mental and moral life is impossible. There is a world of philosophy in this; for if the truth of nature is not good enough to live by, then our three score years and ten are so much waste time and life on this planet is not worth the living. We thus come by another road to the same problem—the value of knowledge and education in terms of life itself, and we see that its proper solution depends not only on the truth we teach or learn but as well on the way this is done. This must be by the dynamic method of research. If we attempt to teach biology, of all subjects, by the method of stuffing sausages, no matter how good the material, we had better not try to teach any at all. In a word the dynamics of the student are quite as important as the dynamics of the subject matter.

To block out a course in dynamic biology for the college and university is a comparatively easy task. And again, natural, active acquaintance with common animals and plants on the part of all children in the grades is hardly more than a matter of common sense. Biology in the high school—as I have been able to study it—presents the most difficult part of our problem; and next to the absolutely necessary and fundamental nature study in the grades, this is, or ought to be made, the next most important stratum in our plan of biological education. So far as my own observation goes, it would seem that this problem is being solved by those schools that undertake to solve it at all, by giving college biology in the high school. This is perhaps the easiest solution for high school teachers, because most of them are college graduates and practically all the biology they know is what they learned in their college courses. This may be well enough if high school pupils are ripe for college biology and the college is ready to vacate this stratum in favor of the high school. But as this plan is being worked high school pupils are compelled to practically repeat a large part of their course, if they wish to continue the subject in college. This leaves our high school biology between the upper and nether millstones.

Just at present college entrance requirements and examinations have placed the most serious obstacle in the way of developing a rational high school course in biology. All of these that I have seen actually require college biology, and, in fact, along the established type-form lines I fail to see how we can put in a high-school course without either telescoping or crowding college biology ahead. The difficulty thus becomes very real—as Professor Birge once pointedly expressed it to me—"If they teach all these types in the high school, what will we have left to teach in the college?" If I thought it advisable to put college biology into the high school, or rather, if I did not think that a course could be devised much better adapted to high school needs than the college course, I think there would be no difficulty in lifting college freshman biology up a story. But it seems to me that dynamic biology offers a better solution. By its aid we can arrange a course which shall not encroach on the college in the least, and, while having its own distinctive aims, in no way subordinate to the college, it shall lay the best possible foundations for more technically scientific study, if the pupil wishes to go farther.

The high school, as part of the public school system, should have its courses co-ordinated with those of the grades. High school biology, under this view, would then form the normal completion of elementary nature study and should aim to fit the great majority who do not study farther for intelligent citizenship in harmony with the forces of living nature. I can hope only to open the discussion of this important question, but from all that I have been able to gather on the subject in the past five years, I am constrained to conclude that the line between practical nature study and technical biology should be drawn between high school and college rather than between the high school and the grades. And I take this position for two distinct reasons. The first is that pupils of high school age are not mature enough and lack the power of thought and the mental perspective to sense the significance of biological types. The note-books may be neat and complete, but when we question the pupils we are likely to find that the underlying ideas have not struck root; *i. e.*, have not found anything in the minds of the pupils with which to form living organic connections. So that I am forced in the main to agree with college instructors who require that the types studied in the high school shall all be worked over again in freshman biology. But when forced to do this the pupils are not only discouraged but disgusted; they take less interest and, in general, derive less benefit from the college work than those who come to it fresh.

The other reason is that there is a large body of biological knowledge, now neglected, which, it seems to me, would prove more valuable to the average citizen and the community than is the body of knowledge now represented by the college course. I was recently informed of a high school class that had spent two-thirds of a year on the anatomy of the frog. Another teacher once said to me: "Most of my pupils will never have any chance to study biology again, and, if I do not give it to them, they will never have the anatomy of the frog. They will then lack even the little remote suggestion that this may give of the structure of their own bodies." I think I see the force of this argument, and still, if its bearing is mainly upon human anatomy, ought not the dissection to be a part of the course in physiology rather than that of general biology? and, at any rate, would it not be more valuable for the pupil to gain a knowledge of the rôle that the amphibia play in the economy of nature? In the one case the knowledge stands in relation to the interests of the community as a whole, while anatomy at best is little more than a means to an end with a special few.

The same argument applies to birds, insects, fishes, reptiles, worms, mollusks and crustaceans and common mammals; to trees and common plants, moulds, mildews, rusts, blights and bacteria. Would not the study of these things as forces in nature strengthen and enhance the value of studying them later as biological types?

To me the strongest argument for work of this character is that we can adopt the method of original investigation at the start and give the pupils the stimulus which comes from finding out things for themselves. In shifting the point of view from dead structures to living activities, the whole science is rejuvenated. The field bristles with original problems of living and practical interest. No costly or complicated instruments are needed; so that no high school need hesitate to introduce such a course because the community cannot afford to buy microscopes and other apparatus. Minds alive and intent upon what is doing in the world about them and sharp eyes are sufficient in this new field to make observations and discoveries of value to the pupils and the community if not to the larger world of science.

Another advantage is that work of this kind can be carried on without the use of many technical terms, and the students will thus not be required to master a difficult language, the value of which they are not prepared to understand, and one which the majority will have no occasion to use after leaving the high school. Many teachers will appreciate the importance of this point, as well as parents who are annoyed by the, to them, meaningless lingo their children bring home from school. The language centres and memories of the pupils will be sufficiently exercised by learning the common names of plants and animals, with, now and then, a scientific name, in case a common name does not exist.

Permit me to cite a few topics by way of illustrating my point of view. I have in my window a jam bottle with a tumbler inverted over it. The bottle contains about an inch of water with some spirogyra and duck weed in it. A strip of blotting paper is glued to the inside of the tumbler for any insect occupant to alight upon, and a narrow strip of paper is fastened to the outside of the tumbler for my records. So much for the apparatus, which any child can get together without expense. Inside I have had now for sixteen days a single Anopheles mosquito. Aug. 20, I allowed her to draw blood (by placing the inverted tumbler on the back of my hand). The morning of Aug. 23, I found 200 eggs floating on the water. She was allowed to bite again, and Aug. 27, I found 198 more eggs. Again she drew blood, and again laid, Sept. 1, 208 eggs. Another meal of blood resulted in a fourth laying of 182 eggs. She has again filled with blood and to all appearances a fifth batch of eggs is forthcoming. The species is Anopheles punctipennis and it is not known definitely whether this species carries malaria or not. I have been rather disappointed in not having a touch of malaria, because I wished not only to settle this point but to obtain a set of blood slides for my class next fall. A few of the eggs in each laying are developing in four tumblers on my study window sill; the rest are preserved in alcohol, enough to furnish specimens of this interesting egg to a class of fifty students. I have simply asked this pestiferous little insect: What can you do? And I have found that she can suck blood and can lay about 800 eggs in sixteen days. I begin to get a glimpse of what one mosquito can do. Suppose these eggs had been laid out of doors and had hatched into, say, 400 female malarial mosquitos to distribute the disease throughout the neighborhood. Then suppose these had succeeded in laying their eggs and so on? Now, follow the subject out into nature, as I have done with my beginning class for the past two years, make a biological survey and locate breeding places, get the records of physicians and see how malaria is distributed about the places where Anopheles are breeding. Then study methods both natural and artificial of controlling this force in nature—all the animals that eat mosquitos in the water, and in the air, birds, bats, frogs and toads, the fishes, newts, salamanders, water bugs, water beetles, dragon fly larvæ, and so on down the list. This is work to keep a class humming and alive with the spirit of genuine research from the start to finish. Then, when interest is keen, the value of lessons on structure and classification is duly appreciated; and the topic may well be closed by reference to books giving the history and fuller discussions of the subject, including the yellow fever problem and that of the coast fevers of Africa. This will serve to show the pupils how they are forging a link in the chain of human knowledge and effort which now encircles the world. Such work students cannot forget. It will become part of their lives, as it is in reality part of the life of nature, and will remain food for both thought and strength as long as they live.

This may serve to show what I mean by a dynamic type. I have outlined the work more fully in my Nature Study, and it is there recommended for lessons in the fifth grade. My object in beginning this particular work so early is mainly to lead the children to appreciate in some degree the value of birds and fishes and other aquatic animals that they are likely to wantonly abuse. But the fact that the study of the type is begun in the grades—and this applies to many other types—is no reason—rather the reverse—for not dealing with it more seriously in the high school or even in the college. In fact, I feel sure I am right when I say that none of this living, dynamic work leaves the stale taste in the mouth of chewing the same cud over again that much of the ordinary anatomical work does.

There is always something fresh and there is no limit, there is room enough for all. It is like swimming in the ocean, where there is plenty of tide and swell to test the metal of the best university investigator; and still sand beaches and tide pools that are safe and delightful for the children in the kindergarten. I have been working on another dynamic type—the common toad—now for seven years, and I have learned more this last year than I did the first and I hope to continue the study for the rest of my life.

The number of such dynamic types is limited by the number of plant and animal species. For public school instruction, however, I am strongly of the opinion that we should hold somewhat closely to types that concern the ordinary daily life of the community. Of course this principle will not exclude the æsthetic types whose chief or only value is their beauty: for beauty in itself and the cultivation of taste are recognized values of life. I have stated my own views on this point fully in my book and elsewhere so far as the work in the grades is concerned. While this instruction centres rather more closely about the child, his interests and property, and that of his own home, many of the lines of work suggested in my book reach out to wider circles of interest and thus connect the home and the child with the community. With the passage from childhood into youth and as a preparation for the various functions of citizenship, it would seem that we might wisely make the main centre for high school biology the life and interests of the city, town or neighborhood. Then in college and university the student would enter naturally into the universe of pure science. While it is thus helpful, perhaps, to picture the subject as a series of concentric spheres of knowledges and interests—the individual, the home, the community, the world; we must be careful not to allow the delimiting surfaces to become too solid. The bounds in each case are those of our own limitations. The child's interests in reality are those of the universal life, but he is not able to trace them beyond his own little sphere. I am often inclined to think, however, that an even graver danger lies in allowing the centres to drop out and leave science a hollow shell with nothing human in it.

To attempt to give further details and specifications would give this paper the character of a text book of high school biology and to deal with the relations of dynamic biology to the college and university courses would take me beyond my present limitations.

Just now the waters are stirred and the urgent need for radical changes in biological instruction is becoming generally felt. Books too numerous to mention have been produced to meet the demand, but none of them strike out boldly enough. They are all written by college and university men, and while some of them contain valuable new and dynamic features, the inclination toward the old familiar ruts has proved too strong, and under new and encouraging titles, they have all turned out to be essentially the old familiar college botany and zoölogy. As a rule high school teachers, while scrupulously trained in details and crammed with facts in college, have not been taught to swim research-wise, and hence, are mortally afraid of venturing beyond their depth. They have nothing to teach except their college botany and zoölogy. They are afraid to tell a pupil: "here is something I do not know; will you help me to find it out?" "Here is a lady beetle. Nobody knows what species of plant lice it will eat; how many it will eat in a day; how many eggs it can lay; how long it lives; will you study it for me and see what you can learn and then tell the class about it? "Yonder is a nest of chipping sparrows. You can sit within a few feet of it without disturbing them. Will you tell us what the parent birds feed the young? How many visits they make to the nest in an hour?" "You have earthworms in your garden. Will you find out how much earth one brings to the surface in a week?" "Here is a tiny maggot that makes it practically impossible for the children in the city, and even our market gardeners, to raise radishes; and here is a bulletin that tells something about it. Will you rear them and preserve specimens of all the different stages you can find or secure and make the subject living and real for us?" Here are fungi enough to go around the class—they are destroying grains, fruits, vegetables and trees. Will you each select one and follow it through its different phases, and then tell us what you have been able to learn?" (A compound microscope is not necessary, even for much work of this kind.)

Permit me to cite a concrete example as it happened in one ot the Worcester high schools. The botany class were studying fungi, each member having been assigned a type to work up and report on to the class. One pupil requested the teacher that he be allowed to take the Black Knot instead of the one given him. She was frank enough to say that she knew nothing about it but that she would be glad to have him find out what he could about it, and give the class the benefit. He went to the library and from the last six volumes of The Experiment Station Record copied off onto postal cards the numbers and titles of all the bulletins on the black knot, addressed the cards and within a week had practically everything written on his subject during this time. He then went to work, hunted through the woods and collected the fungus as it grows on native plums and wild cherries and made a survey of enough of the city to enable him to form an intelligent estimate of its prevalence on cultivated fruits. He mounted a number of typical specimens in a glass case for demonstration and finally presented his results on the life history, distribution and treatment of the black knot in a carefully prepared lecture which occupied an entire period of the class. A reporter found out what he was doing and presented the subject to the Worcester public in about two columns in one of the local papers.

This account is not complete without adding that the lot next to this young man's home contained a plum orchard of twenty trees in the last stages of destruction from black knot. This was a menace to his own trees and to those of the neighborhood. Since the people who rented the place knew and cared nothing about them, he made out and got signed in duplicate an agreement to treat and care for the trees for half the product. His father later bought the lot on which the trees stand, and they are now in vigorous bearing. The young man has just given me a list of ten prizes that he has taken for plums in fairs and horticultural exhibits. He is now about to enter his senior year in college and has the fixed ambition to prepare himself to teach biology. I recently asked him: "What do you think of the work you did on black knot in the high school? Was it a waste of time?" "Well," he said, "it exactly fitted my particular bent and on that account, I think I got more real good out of it than from any other one thing in my high school course."

I have discussed this subject with scores of high school teachers and I have found two characteristic reactions. Practically all of them believe in and would like to do this kind of work. Many say: "This is all very fine, but I do not know anything about these things and I can't teach anything I do not know. I cannot be telling my classes all the time: I do not know this, I do not know that. I would soon lose my job. I must 'change the subject,' dissimulate or even lie rather than say 'I don't know.' You know perfectly well that people think a college graduate ought to know everything. We are obliged to take people as we find them and work the delusion for all it is worth."

The other class of teachers say: "Yes, this is the work we ought to be doing in the high-school; but there is the valley of the shadow of death, the technical college requirement examination, ahead of my pupils. If they cannot describe the sporogonium and the sporophyte and gametophite generations of Marchantia polymorpha, the protopodite, exopodite, endopodite and branchiopodite of Astacus fluviatilis or Cambarus; the number of segments in the body and the number of joints in the leg of Caloptenus femur-rubrum and Musca domestica; tell all about the foods, habitats and distribution of Nerreis virens, Autolytus, Lepidonotus, Amphitrite, Serpula, Nephelis and Clepsine, and so on *ad infinitum;* they may fail to 'pass,' or enter college with conditions, and I shall lose caste and my school will be disgraced.'

This is what I mean by saying that college entrance requirements and examinations as they are now being formulated present the most serious obstacle to a rational high school biology. As I have studied them, I have often said to myself, "we college instructors must be doing this in our sleep and while dreaming that we are setting examinations for our college students."

Here are a few examples from my collection of such examination questions:

"How do you know that the protoplasm of the plant and animal cell is identical?"

Discuss the "ovule and pollen in the reproduction of plants."

Discuss "the leaves of insectivorous plants."

Discuss "respiration in plants and how to show it experimentally."

Discuss "the general path of ascending water (sap) in the stem, and a way in which this path may be shown experimentally."

"Of how many segments is each foot (of a beetle) composed?"

"How many segments in the leg" (of a fly)?

"How many segments in the leg" (of Lithobius)?

"How can you homologize with one another the swimmerets, the legs and the mouth parth" (of the crayfish)?

"What is the gill formula of the animal in hand" (crayfish)?

Are not all of these typical questions in college botany and zoölogy? And I might add: are not many of them to the discredit to these subjects as they are commonly taught in college?

I do not relish being dubbed a "nihilist" or a "distructive critic;" and it does not seem just to the suggestions of a positive character offered above that such should be my lot. But to make assurance doubly sure, permit me to give a few specimen questions that seem to me suitable for college entrance requirements:"

Describe the flowers and fruit of the white pine, stating the seasons at which the flowers appear and the seeds are ripe. (Substitute the names of about thirty of our most important forest trees for as many questions.)

Discuss the poisonous plants of your locality and methods of dealing with them.

What weeds are outlawed by your State?

What native plants are in danger of extermination and what methods should be adopted to prevent this?

Name the ferns with which you are familiar.

Define the functions of leaves, stems and roots.

Name the parts of an apple blossom and tell what function each performs.

Describe the black knot and methods of dealing with it. (Substitute the names of about forty common parasitic fungi—moulds, blights, mildews, rusts and smuts—for as many questions.)

How may an epidemic of typhoid fever be caused? How prevented?

Describe the food and feeding habits of the common toad.

Name the frogs, tree frogs and salamanders with which you are familiar.

Discuss the food and economic status of the robin. (Substitute the names of about one hundred of our more important birds for as many questions.)

Outline the laws for the protection of game and insectivorous birds in your State.

Describe the life history and natural enemies of the codling moth. (Substitute the names of about one hundred and fifty of our most important insects for as many questions.)

With what fresh water fishes are you familiar? Give the spawning habits and season (of any one of about twenty common species).

If a committee of college instructors could be brought together and it could agree upon a carefully prepared and thoroughly discussed plan of entrance requirements in biology along lines approximating those indicated by the above questions, it would be in my estimation the greatest service the college could render to the public and to the secondary schools. A separate paper might be written upon the influence the body of knowledge underlying such requirements would exert upon the life of the country and the way in which it might bridge the wide gulf which now separates science and everyday life. Students might then come to the college alive and eager to grasp the tools and avail themselves of the resources of science, because they had actually begun to wonder how the infinite variety of living forms could be reduced to an orderly system. Such an upheaval of new life as there would be might rattle some of the dry bones in high places, but that would not be the least of its advantages. If colleges are to continue to educate teachers for secondary schools, the sooner we can shake our courses out of the condition of dry rot and give our students something to teach, the better. To complete this discussion I hope, ere long, to present a companion paper on dynamic biology in the college and university.

To those high school teachers who cannot bring themselves to think that the theoretical relations are not the most important part of their courses I beg to suggest that they read their Darwin and note how he arrived at his great generalization by just such studies as I advocate. It is his *method* that we should strive to give to our students and then we can let the results take care of themselves. Darwin, himself, opened up the field of dynamic biology by emphasizing the fact that small forces enormously multiplied and working continuously accomplish inconceivably great results. His work upon coral reefs and especially on earthworms and the formation of vegetable mould are typical cases in point. And with the latter it is significant to note that it was one of his earliest scientific interests, that he kept it alive to the end and finally brought it out as his last great contribution to science. By an application of his method a like revelation awaits the study of an infinite number of other common forms.

And finally, to teach laborious and technical schemes of classification before the child has anything that he knows or cares to classify; to give minute details of internal or external structure of things the child has never heard of (and will never hear of again, if he can help it); to present abstract relations to minds that know little about the things they relate; to propound world encircling theories to children who have no adequate knowledge of the facts they attempt to explain: Do these things not suggest trying to feed babies with the combings of gray hairs?

Dynamic Biology in the College.

II.

DYNAMIC BIOLOGY IN THE COLLEGE COURSE.

By C. F. Hodge, Clark University.

II.

Huxley cast the mould of our present course in biology about 1870. At that time his work was the stroke of a master genius and marked an epoch in modern biological instruction. In symmetry and perfection the course is a crystal of logic, and I do not see how any one who followed it, either under the great master himself or under his co-author, Martin, could ever fail in appreciation of its value or cease to regard this course with a certain degree of reverence. Still, as one who took the course with Martin, I feel that the time has come for a complete metamorphosis and moult. If I may be permitted to carry out the figure a little farther, it seems to me that the Huxley-Martin course represents a chrysalis stage in the development of the science—a time of ideal internal perfecting—and that it is to be succeeded by the adult stage in which the biologist must take his place as an active power in the community.

Transformations and moultings are difficult processes at best. The problem involved in the present instance is to save all that is best in the past and make the necessary adjustments to the demands of the present. That radical changes are imperative, is manifest on all sides. "Do you still use Huxley and Martin in the biological course at the Hopkins?" I recently asked the professor in charge. "No," he said, "we have not been able to work with that for a number of years. We use ———'s book, but it is not adapted to our course, and there is no book that is." Within a year the entire "biological" department in the high school of a progressive New England city was thrown out, ostensibly, on account of lack of room, but really, I think, because it had degenerated into technical, college botany and zoölogy. The recent action of the Regents of the State of New York, in discontinuing the old courses in botany and zoölogy in the secondary schools, putting *biology* in their place, is another case in point. In adapting the work to the required three years' basis at Clark, it was proposed to omit "freshman biology" altogether "as not of much account anyway." After discussing the matter, however, President Wright finally said: "Well, if we can have a new deal in freshman biology, there is not a subject I would rather have in the curriculum."

I propose to describe in some detail this "new deal" as it has taken form during the past three years. Before doing this, however, we shall need to follow the course of biological instruction from Huxley's time down to the present. Some may be inclined to think that there have been a number of "moults" already, but it seems to me that these are all to be classified under internal movements of resorption and inversion in preparation for the final change.

Huxley defined science as "trained and organized common sense." Before that, science was "classified and arranged knowledge." Before Huxley inaugurated the biological epoch, we had botany and zoölogy as two separate museums with the specimens classified, arranged and named. They were all dead and there was little common sense in either their classification, arrangement or naming. There were no organizing or vitalizing principles that united the two museums. Since the handling and study of dead animals and plants is a disagreeable task at best, most, if not all, of our courses in botany and zoölogy were done by the text-book method. Our heritage from this old regime is still in evidence in the fact that in some institutions the botanists and zoölogists are divided into not only distinct but jealous camps. "What a chance you have for these experiments," I remarked to a zoölogist friend in a large university, "with a greenhouse of your own." "You are greatly mistaken," he replied, "that greenhouse belongs to the botanical department. They have nothing in it, but a zoölogist does n't dare show his head inside." And then I made the mental note that there was very little in his magnificent aquaria and that probably no botanist need apply. In another instance a gall in a plant was sent to the botanist of a college, with a request for information. The botanist promptly sent it over to the zoölogical department as a case of insect work. The zoölogist reported "no insects present, probably a fungus;" and back it went to the botanist. I understand it finally dropped between the departments.

Biology is defined as the study of living things in their widest relations. It is inherently dynamic. It deals with the forces which act and interact upon organisms and which they themselves exert. I have emphasized the close relation which exists between dynamic biology and evolution in the preceding paper; and, while the science was christened by Lamark and Trivarinus in 1802, as a reincarnation of the older evolutionary thought of the Greeks, and as an expression of the inadequate attempts toward a consistent philosophy of evolution of their time, it was really born in the evolutionary work of Huxley. For him the biological view was a logical necessity. He could no longer be either a botanist or a zoölogist. As he says in the preface to his first edition:

> "Very soon after I began to teach Natural History, or what we now call Biology, at the Royal School of Mines, some twenty years ago, I arrived at the conviction that the study of living bodies is really one discipline, which is divided into Botany and Zoölogy simply as a matter of convenience; and that the scientific zoölogist should no more be ignorant of the fundamental phenomena of vegetable life, than the scientific Botanist of those of animal existence."

The old botany and zoölogy could give us only at best an imperfect philosophy of plants and animals. What we need is a philosophy of life itself.

Huxley's series of types is a list to conjure by. I name them in the order in which they occur in his book: Yeast, Protococcus, Amœba, bacteria,—then up the plant series with—Moulds, Stoneworts, Ferns, flowering plants—then back to the protozoa and up the animal side with—Vorticella, Hydra, Fresh-water Mussel, Crayfish, Frog. For the mature student, this logical sequence from the simple to the complex on the side of both animals and plants could leave little to be desired. Every one who followed this course in the laboratory came out by logical necessity an evolutionist and no teaching of the dogma was necessary. In fact this was tactfully held in abeyance, each member of the class being allowed to draw his own conclusions from the facts themselves. I well remember on completing this course in the Johns Hopkins our class had to wait upon Dr. Martin by special committee with the request that he give some additional lectures on the doctrine of evolution itself.

I should add, perhaps, that the course was filled out by a number of types, like Spirogyra, Vaucheria and Polytrichum, Earthworm, Perch, Turtle, Pigeon and Rat; and the work was concluded with the embryology of the chick. This gathered up all the loose ends and tied them fast. As given by Dr. Martin himself, I still look back upon it as the most ideal course I ever had, and in it we saw in microcosm a vision of the evolutionary process,—a form actually weaving its organization from a single cell, a protozoan, to a vertebrate, all in three days time.

I must also add that coming to this course as a mature post-graduate student my intense enjoyment of it has left me a confirmed stickler for the logical order. As a pure discipline in inductive reasoning nothing can supplant it. Still with immature students I realize that to begin with the Protozoa and Protophyta, the one-celled animals and plants, is really casting pearls before newly hatched chicks. They need gravel first and unless they have it, this most ideal and suggestive part of the whole course is passed over before they are able to think what it means and they may be biologically crippled in consequence. How I avoid this in my present course will be cleared up a little later. Martin clung to the logical order to the end, but Huxley, after a few years' trial, changed it completely to what we may call a more natural or psychological order.

The reader should at this point refer to Huxley's preface to his "Revised Edition" (it should be read in full) in which he says:

> "But besides these changes, the reader who compares the two editions will observe that the order in which the subjects are presented is completely changed. In the first edition the lowest forms of life were first dealt with; the series of plants followed in ascending order; and then the series of animals, from the Bell animalcule upwards to the Frog.
>
> "No doubt there is much to be said for the principle of this arrangement, which leads the student from the study of simple to that of complex phenomena; but the experience of the Lecture room and the Laboratory taught me that philosophical as it might be in the theory, it had defects in practice.
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> . . . .
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> "After two or three years' trial of this road from the simple to the complex, I became so thoroughly convinced that the way from the known to the unknown was easier for students, that I reversed my course, and began with such animals as a Rabbit or a Frog, about which everybody knows something, while their anatomy and physiology is illustrated by innumerable analogies with those of our own bodies."

Martin never admitted the cogency of this reasoning, but maintained that since we must descend to the cellular elements in order to an intelligent understanding of physiological process and anatomical organization, and since the bulk of the work dealt with minute and technical anatomical details, this order really plunged the student into not only one "unknown" but into a "most bewildering and complicated maze of unknowns." The first edition devotes 108 pages to the Frog, the Revised, 172, and other topics are likewise amplified, so that from a trim little book of 266 pages, the Revised Edition has grown to 498 pages. When Martin saw the Revised Edition, I heard him say in disgust: "It is a clear case of fatty degeneration."

I think Martin was right on both counts—as to the bewilderment of anatomical details, which makes the new edition unusable, and as to the "fatty degeneration," which vitiates the whole and makes it undigestible. Some may be inclined to think that this is raking up dead issues; but to one who is grappling with the problem of biological education in the college and university and trying to co-ordinate with this elementary instruction and the present needs of the masses they are still very much alive. And I hope to show how, by adopting the dynamic view-point, we may be greatly aided in escaping the difficulties of too great anatomical and unessential detail and still have a mentally and morally virile course.

Huxley was a biologist and physiologist by inclination but was forced to be an anatomist by the stress of his battle for evolution. Martin had already passed beyond the heat of this conflict and was a biologist and physiologist to the end. While Darwin did most of the work, it fell to Huxley's lot to fight his battles; and known as he is as the "bull-dog of evolution," since the struggle was fought out on the details of comparative anatomy, his position compelled him to be the foremost master of his data. Naturally the course of instruction which he formulated then was dominated by this fact. It fitted the time to perfection and was a veritable sowing of dragons' teeth to raise up champions for the cause.

Now the conflict is over, evolution has triumphed, and has become the common possession of thinking men. Is it not time to pause and ask ourselves whether a war measure adopted amid the clash of arms should be continued in force indefinitely? Is there no present conflict? Are there not modern issues that should largely dominate our choice of matter and method to-day? Is it less true now that "My people are destroyed for lack of knowledge?" Is the ancient monster of ignorance and prejudice and unfaith in life any less grim to-day? And when the people ask for bread, how long can the biologist put them off with: "Here is a most interesting fossil, will it not do as well?" And when they ask for a fish, how long shall we continue to offer them a type specimen of a snake instead?

The problem is extremely complicated, and in trying to weigh the values which shall determine the elements of our course, we can hardly hope to avoid mistakes and incur more or less serious misunderstandings. There are, of course, new issues and these have influenced modifications of our present courses in biology. Before speaking of these, however, we need to emphasize especially one point with reference to the Huxley-Martin phase of biological instruction. It was splendidly adapted to specialists. It is still a good course for beginners on the road toward medicine or toward professional biology. For those—and they ought to be the vast majority—who look to biology for help toward a liberal education and a sound philosophy of life, it is simply preposterous.

T. Jeffrey Parker's Elementary Biology appeared in 1891. The author is essentially a comparative anatomist and a morphological zoölogist, to the teaching of which subjects he has rendered illustrious services. He is thus well fitted to give us an ultra perfect type-specimen course of essentially form and structure studies. Still the physiological side is good and, apart from the lack of adequate suggestion for experiment, is all that could be desired. Parker holds to Huxley's original logical order as of too "immense advantage" for the student to be lightly given up, but meets the difficulty by beginning in the laboratory with some preliminary study of a higher animal and plant, more purely physiological and biological. And he also makes the significant statement in his preface that this kind of work might be extended with advantage: "If there were no limitations as to time, and if it were possible to avoid altogether the valley of the shadow of the coming examination." This latter raises the interesting question whether leaders in rapidly growing sciences should maim their students or educate or, failing in that, dynamite their examining boards.

Parker's course emphasizes another point that is most timely. There is already a very general feeling that mere laboratory work may be overdone. There are so many facts, and they are all so "interesting and important" that the most careful of us are in danger of loading the student so heavily with facts that he has no time or energy to think. With this danger in mind, I think that all teachers of biology, who are not too young to have grasped the "ideas" or are not petrified in the Gradgrind mould, will agree with Parker when he says: "That the main object of teaching biology as a part of a liberal education is to familiarize the student not so much with the facts as with the ideas of science."

Personally I feel that the greatest defect in Parker's book is its flawless perfection and completeness. I even hesitate to use it with my own students; because it runs along so smoothly, satisfyingly and restfully; because it typifies that "just-so," *ipse dixit* lecture style that soothes to sleep rather than stimulates to effort, that I fear the students will come out satisfied with what they know rather than eager investigators. In this I do not mean, of course, investigators in biology in the technical sense but, what is infinitely more important, investigators into the problems of their own lives.

Finally we now pass to a type of biological course which places the main emphasis upon the cell as the structural and physiological unit. Pre-eminent in this field is Sedgwick and Wilson's General Biology. No one can question for a moment the importance of the problems in this field to the highly specialized biologist and through him to the public at large. They represent vital and present issues about which the materials and methods of a course intended to produce specialists might group themselves naturally enough. The science of cellular structures and activities, cytology, forms in many respects the present growing tip of biology, and must furnish an increasingly large mass of foundation material for physiology and hygiene; and, as applied to the reproductive cells, forms the natural basis for a science of heredity.

The feature of this course is the study of few types—Earthworm and Fern—so exhaustively and with such careful attention to fundamental processes and principles that the student will be equipped to study any desired form of animal or plant in a similar way. Theoretically this would seem well adapted to produce specialized investigators. On the side of practical working, however, we are brought to realize that technical equipment can never make an investigator. He must have a tremendous amount of motive power to keep his technique in working order.

From a well developed understanding of the subject as a whole, he must feel that his problem is worthy of his best efforts. Until we give him the "ideas" that can supply this motive power, the danger in forcing the student to the apex of specialization is that he feels that he has already reached the goal. We tire him out so that instead of being strengthened and inspired to go on, he lays down the work with a sigh of relief.

I am inclined to place most of the work in all courses of this character in the stratum of university instruction. For the college the bulk of the course should be on a much lower plane, much more directly and obviously related to the commoner problems of life, and requiring much less specialized technique.

In tracing the progress of biological instruction from Huxley's time down to the present we have seen that the tendency has been toward ever higher and higher specialization. The biologists have flown off on a tangent until they form a little group by themselves, working on their special problems, talking a language of their own and writing books for one another. In the main they have gone far beyond the hail of educated people in other professions. As the science of life itself it would seem that biology should touch the common life more intimately than any other body of knowledge. Is it not true that even now we need another Huxley to bring the science and the world together again?

In 1868, while Huxley was yet a biologist, he wrote an inspired passage—I often call it the finest in scientific literature—which I always read to the class as the text of our year's work. It is all so good, and I see it referred to so rarely, I give it in full.

> "And by way of beginning, let us ask ourselves—What is education? Above all things, What is our ideal of a thoroughly liberal education?—of that education which, if we could begin life again, we would give ourselves—of that education which, if we could mould the fates to our own will, we would give our children? Well, I know not what may

be your conceptions upon this matter, but I will tell you mine, and I hope I shall find that our views are not very discrepant.

"Suppose it were perfectly certain that the life and fortune of every one of us would, one day or other, depend on his winning or losing a game at chess. Don't you think that we should all consider it to be a primary duty to learn at least the names and moves of the pieces; to have a notion of a gambit, and a keen eye for all the means of giving and getting out of check? Do you not think that we should look with a disapprobation amounting to scorn, upon the father who allowed his son, or the state which allowed its members, to grow up without knowing a pawn from a knight?

"Yet it is a very plain and elementary truth, that the life, the fortune, and the happiness of every one of us, and, more or less, of those who are connected with us, do depend upon our knowing something of the rules of a game infinitely more difficult and complicated than chess. It is a game which has been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chess-board is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of Nature. The player on the other side is hidden from us. We know that his play is always fair, just and patient. But also we know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well, the highest stakes are paid, with that sort of overflowing generosity with which the strong shows delight in strength. And one who plays ill is checkmated—without haste, but without remorse.

"My metaphor will remind some of you of the famous picture in which Retzsch has depicted Satan playing at chess with a man for his soul. Substitute for the mocking fiend in that picture a calm, strong angel who is playing for love, as we say, and would rather lose than win—and I should accept it as an image of human life.

"Well what I mean by education is learning the rules of this mighty game. In other words, education is the instruction of the intellect in the laws of Nature, under which name I include not merely things and their forces, but men and their ways; and the fashioning of the affections and of the will into an earnest and loving desire to move in harmony with those laws. For me, education means neither more nor less than this. Anything which professes to call itself education must be tried by this standard, and if it fails to stand the test, I will not call it education, whatever may be the force of authority, or of numbers, upon the other side." (A liberal Education and where to Find it. Science and Education Essays, pp. 81 ff. Appleton & Co., 1896.)

"To learn what is true in order to do what is right," is another way Huxley had of stating his position; and I have often asked myself what possible connection the learning of a great many of the anatomical details, even in his first edition, could have not only with "doing what is right" but with doing anything at all in case of the non-special student. As he says in his first preface: "The chief labor in drawing up these instructions has fallen on Dr. Martin." Much as I cherish his memory, I think we must remember that he was a young man when he worked out the details of his course. He was a specialist and had not studied principles or methods of education particularly, and he gave the course a distinct coloring of the period.

I have thus come to feel that this whole scheme of biological education has been accorded far more consideration than its due, and has long outlived its usefulness for all purposes of general culture, and I take my leave of it in the confident hope that we shall now be able to find a course better adapted to the needs of the time.

Within the last thirty years real university work has developed to a high degree of efficiency in this country and the preparation of specialists should be relegated to that. Aside from some preparation of a premedical character or for elementary teaching, the problem in the college is to develop courses in biological subjects that shall have the greatest culture value possible; and this, with reference to good citizenship and intelligent living rather than to future specialization.

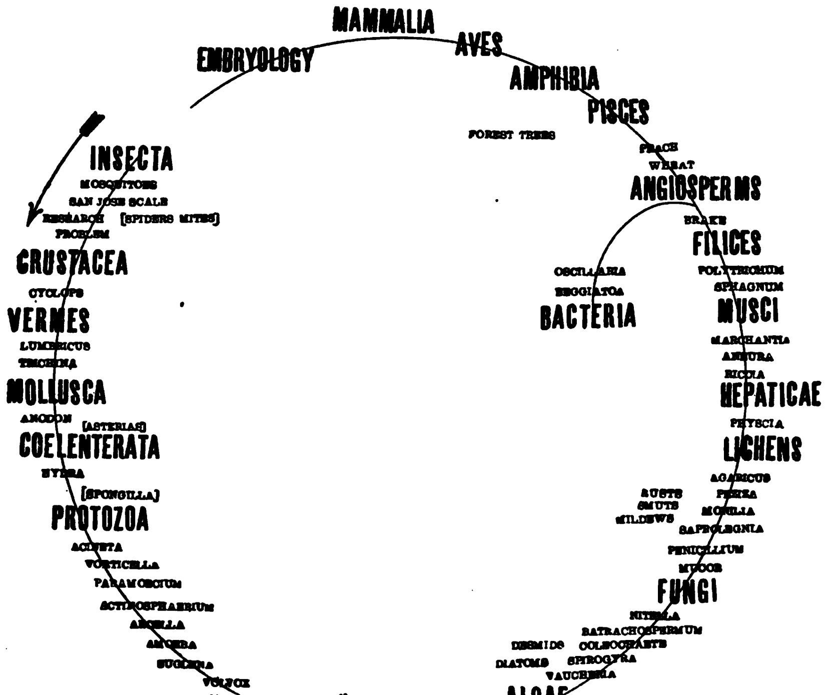
In the Collegiate Department of Clark University this problem is being solved as follows: I shall describe in detail only the first-year biology, merely naming the other courses in order to show its setting.

First Year.	Second Year.	Third Year.
Dynamic Biology.	Zoölogy, Invertebrate and Vertebrate. Vertebrate Morphology and Embryology (as premedical). Botany, Structural, Systematic and Ecological.	Animal Physiology and Hygiene and Histology, (including a brief course in Bacteriology). Plant Physiology, Histology and Plant Diseases.

The laboratory work is made somewhat different in most of the courses for general culture and pre-professional students.

Study Living Things as Forces in Nature. This, which may be taken as the motto of the first year's course, expresses the change of point of view from the anatomical to the dynamic. This change, of course, furnishes a different set of criteria, under which to select and arrange the subject matter. Still the anatomical type series has recognized scientific value and the fact that this is merely subordinated and not disregarded will be clear as we proceed with the details of the course. The question, then, becomes—What forces in nature have the greatest educational value and what types best serve to exemplify them? We must, of course, answer it strictly with reference to the attainments and needs of our students. Nothing is farther from my mind than to wish to see the course in dynamic biology become as rigid and fixed as the one I hope it may supersede. In fact, it seems to me that it has internal life and plasticity which shall keep it growing. It should differ in important details in different localities, but the greatest change must come from the changing needs of successive classes. Especially now that nature study is being developed in the public schools, as soon as the men come from the high school with sufficient knowledge of living things, insects, birds, and other common animals, trees, native plants, fungi, etc., to make them good citizens and enable them to play their part in the game of life, it will be time to take another decided moult out of the course I have suggested below. There is plenty of room ahead for that, however, and I only hope the time for it may come soon.

The dynamic types and the order in which they are studied may be seen at a glance in the following diagram.



From the order in which the types are studied it will be seen that ours resembles Huxley's revised course; and, clearly, we may be as "logical" in passing from the complex to the simple as the reverse. We have here the double advantage of gliding easily down on the animal side, thereby gaining momentum to rise through an ideal series of plant forms on the other side. And there is a distinct advantage in studying the vertebrates, including a glimpse of embryology at the close, as the natural completion of the year's study. The immense superiority and advantage of vertebrate structure and organization over all other plans cannot be properly sensed unless this order is followed.

Dynamically, insects are of the utmost importance, and zoölogically this is the age of insects. There are more than ten times as many insect species as of any other animals; and practically insects form the best possible introduction to the course. They furnish an abundance of forms with which to develop ideas of animal classification without even mentioning "cells" in the introductory lessons. Best of all, fully half the laboratory work through September and October may be done out of doors, a feature to which I attach great importance throughout the course. So far as practicable I would have the student find his specimens for himself and study them in their natural environment first and then bring them into the laboratory for further examination. In practice, however, this cannot be done without too great sacrifice of time and most of the types are not in the best condition for study at the season when the class must do the work; but many of their own specimens the students can collect for themselves, and many more, for the next year's class. All may thus be given incentive and experience in collecting in the field.

During the winter months—from November to April—the laboratory work is almost entirely indoors. Then again from April to June fishes, reptiles, amphibia and birds, together with trees and many points in the plant series purposely left to this time,—supply both matter and motive for out-door study.

After a preliminary lecture hour, in which, however, the class is *not* told what an insect is, the students are provided with collecting outfits and directed to gather in everything they know or think is an insect and nothing they think is not an insect. They are told to turn over logs and stones, tear to pieces old stumps, examine the bark of trees and hunt among the foliage and in the chinks and crevices of fences and buildings. The result of a three-hour laboratory period spent in this way should be the collection of from 100 to 1,000 specimens. We realize, however, how different this is from the usual methods when a number of the class come in without a single insect. "Could n't find any!" One man, a six footer, told me in all seriousness that he had hunted faithfully all the afternoon and did succeed in catching one mosquito, but—"it got away from me!" Generally, however, there will be a few in the class who will bring in enough to distribute to the rest and as a last resort requisition may be made upon the laboratory stock. In a lecture period, having named and described in general terms the parts of an insect, we devote the next laboratory exercise to the attempt on the part of each student to classify his material. Along with this work a brief study of the external anatomy of the locust, requiring outline drawings, is made to familiarize the student with the data of classification. Then follows a standard scheme for the classification of insects and the student is furnished a mimeograph copy which he learns to use as an artificial key, and by the aid of which he selects from his own collected material one or more specimens illustrating each class and mounts them for future reference and study.

The next question is: What insect or insects do we wish to pay special attention to as dynamic types? In response to local conditions we selected the mosquitoes and the San Jose scale and have used them for the three years past, and shall probably continue to do so as long as they represent interesting dynamic problems. In addition to these, however, and in connection with students' collections and out-door laboratory work a number of other insects of importance both injurious and beneficial were discussed. On leaving the subject of insects, each member of the class is allowed to choose some insect, or group of insects, to work out during the remainder of the year the life history, foods, natural enemies and general dynamic relations. Toward the end of the year the student presents his results in the form of a lecture before the class; and, at the outset, he is informed that the manner in which this investigation is done will count heavily for or against his rank in the class. I know of no device which serves so well to develop initiative and reveal any facility for investigation which may exist in the class.

The object of all this work with insects is not so much information, or knowledge of anatomy or of systematic discrimination of minute details, or training of the powers of observation. These are only incidental and subordinate results of the chief purpose, which is to introduce the student to the dynamic problem of modern entomology; to actually let him try his hand at it, and learn how it feels to work in the field himself.

I shall not be able to enter even thus fully into details with many of the other topics. I consider one of the chief values to the student of this year in general biology to be the glimpse he gets of the different departments of the science. I look upon the course as a hallway through which to enter any desired department and if his view does not lead to specialization, we may surely make the course yield intelligent interests.

The insect work is on the whole rather easy, on the surface of things, and though the class has been analyzing mosquitoes by their claws, palpi and wing venation, and has studied the mouth parts of the San Jose scale with the compound microscope, it has had no really tough propositions to test its metal. Something of this sort must come pretty early in the course, and it happens conveniently that the Crustacea follow the insects, and that we have a type which might have been made to order for the express purpose of demonstrating how much organization can be crowded into an almost microscopic animal. Cyclops strikes the students like lightning out of a cloudless sky, and they go down before it in heaps. They grovel and groan and give it up. But, finally, when asked whether they really intend to be beaten by such a little creature, most of them straighten their backs and do some creditable work. Of course they have laboratory specimens of lobster, crawfish and a number of the crabs for comparison, and they do a little work with Daphne, and have their attention called to a number of the parasitic marine copepods. A further reason for selecting this type is that dynamically the copepods are probably of greater biological importance as furnishing a food supply for marine and fresh water fishes than all the other groups combined.

With the earthworm as the type of annelid the first serious work is done with internal anatomy. This is studied out organ for organ and cell for cell, but from the point of view of discovering the mechanism by means of which vegetable mould is formed. Other forms are used in a subsidiary way, viz., the tape worm trichina and other nemetodes, flukes, etc., which have dynamic problems associated with them.

The fresh water clam is studied largely from the anatomical standpoint, except that experiments and observations emphasize its foods and its water filtering power. Hydra is used in the usual way as a morphological type.

As many and as varied protozoan forms are studied as time will permit—Acineta, Paramœcium, Stylonichia, Stentor, Vorticella, Actinospherium, Arcella, Amœba, Euglena, Volvox; and special attention is directed to the water-polluting forms—Dinobryin, Synura, Uroglena, Glenodinium and Peridinium. Emphasis is also placed upon the Sporozoa in relation to malaria and other diseases and upon certain Amœbas which cause dysentery. Studied dynamically, with regard to variety of device and mechanism for movement, for securing food and in relation to reproductive power, no part of the course is of greater suggestive value to the student. No forms are so well adapted for showing the plasticity, the tireless activity and the infinite resourcefulness of living matter. All this supplies additional reasons for placing the protozoa in the very heart of our biological course.

Ascent through the plant series is now easy and may be rapidly made, the rather complete list of type forms being correlated and used in the laboratory in such wise as to assist rather than hinder the progress of the class. The types are studied in much the usual way, the dynamic features being subordination of structural details while emphasizing the active processes of growth and transformation of food materials. Everything is studied alive and at work, the attempt is made to show the class as many active processes—cell division, conjugation, starch formation, etc., as possible,—special stress being placed on the great reproductive energy of many of the lower forms. For all this the types and the order in which they are introduced speak for themselves. Among the algæ special attention is again called to the water-polluting forms—Asterionella, Anabæna, Clathrocystis, Cœlosphœrium and Aphanizomenon.

The fungi are taken up from much the same general point of view as the insects, prominence being given to the dynamic and economic problems involved. Members of the class are encouraged to work out research-wise the life history of such forms as Monilia, black knot, Peronospera, peach-leaf-curl and other rusts, mildews, smuts and blights. In this way the students are introduced into the important problems of plant diseases.

The fern is used as the type for the minute study of a plant much as the earthworm is on the animal side, and it is worked out cell for cell in root, rhizome and leaf. Thorough work here renders very facile the following studies of the structure of seeds, for which sprouting wheat and the peach serve as excellent types, historic, dynamic and suggestive to the core.

The bacteria are purposely pushed out of their logical position to the end of the laboratory series of plant studies on account of their manifold dynamic relations. A number of the standard culture media are made, demonstration-wise, in the laboratory and distributed in tubes and Petri dishes so that each student may make plantings from the air, water and dust, fly tracks, etc., and thus get a practical insight into bacteriological methods. By the courtesy of Dr. Moore samples ot nitrogen fixing bacteria were obtained from Washington, and clover seed was inoculated and planted in pots in the laboratory. Comparative plots were also planted in a garden near by and several of the students did the same in their own gardens. Stained sections of root tubercles were next studied. Of course no culture experiments with pathogenic bacteria are attempted in such an elementary course, although sealed cultures are used for demonstration and prepared slides of a number of important forms are used in a similar way. For example, by the kindness of the physicians in charge a hundred sputum slides were obtained from the sanitarium at Rutland and each student works over ten marked slides and passes in a written diagnosis as though he were a member of the hospital staff.

The text-book for part of this subject is the Board of Health Reports of the City of Worcester, and, after discussing the general topic of city sanitation and pointing out the diseases that are clearly known to be of bacterial origin, each member of the class is required to go over the entire report, without consultation with others, and hand in a written report giving his estimate of the number of preventable cases of death or disease for the year.

In this way the student is given a clear, practical notion of the rôle bacteria play in the economy of nature—as symbiotic, saprophytic and parasitic, and is thus introduced into the problems of modern bacteriology.

From this point on—which should be about the first of April—the course branches into a number of individual and small-group lines. The main branch, only part of the laboratory work of which is required of the whole class, passes up into vertebrate morphology and biology with a fish, frog, bird and mammal as the types. The pre-medical men, and those who are preparing to teach biology, study the types in much the usual way; but even here experience of the department has indicated that the structural may well be largely subordinated to the biological as giving the more fundamental and educational values for first-year work. The tendency is, thus, to crowd the purely morphological details more and more over into the two succeeding years, giving them a somewhat definitely specialized character.

The outline of this work is, briefly, Fishes, general plan of organization; common species with habitats, foods and spawning habits and seasons, numbers of eggs produced, methods of fishing to be employed in order to keep waters properly stocked.

The Batrachia are studied in much the same way except that the pre-professional section of the class spend more time with the anatomy, and the eggs are used for the outlines of vertebrate embryology—instead of the chick as used in Dr. Martin's course. More attention is also paid to the insectivorous habits of the group by way of feeding tests in the laboratory. The spawning habits and seasons, too, have been more carefully followed by the successive classes in the hope of publishing a complete account of this subject for all our common species of frogs, tree frogs, toads and salamanders. This is genuine investigation in which all the class take part during the spring months—and in some cases the study is continued voluntarily throughout the summer vacation—and the results will fill a serious gap in our natural history. These animals are practically all more or less important insect destroyers, and knowledge along these lines must come to underlie all practical work calculated to maintain the different species at their greatest efficiency.

The work with turtles and snakes is little more than incidental. A number of specimens are always collected during out-door laboratory periods and these may be utilized by some member of the class for feeding tests, and they also serve to demonstrate in a general way the various types of organization and some of the salient biological relations.

The study of birds is begun early in the fall with a brief statement that each member of the class will be required to know at least one hundred common species and be able by the end of the course to describe them as to color, markings, notes and songs, migration periods, habitats, nesting habits, and especially foods. By thus early sketching the plan of work for the year the student is enabled to organize all the knowledge he already has and utilize every opportunity for observation which may render his knowledge more complete. His attention is also called to a number of standard bird books including many of the U. S. Government Reports which give the foods and economic values of different species. These are kept for reference on a shelf in the laboratory. He is also required to supply himself with a field note book, and this is inspected from time to time, suggestions made, and then finally graded at the end of the year according to amount of work accomplished.

The species used as a dynamic and anatomical type is the English sparrow. The Bulletin of the United States Department of Agriculture on the English Sparrow in North America is referred to in detail on the foods and economic status of the species. The students are directed to note carefully observations under these heads, especially with regard to the relations between the English sparrow and native species, and finally the most effective methods of dealing with the intruders are considered.

Little work is attempted with mammals beyond noting general organization, and position in the animal series, leaving practically all the anatomy and special physiology to succeeding years. Toward the end, a little review work and some general suggestions are directed toward comparing the nervous systems of the various invertebrate and vertebrate types to introduce the student to the problems of modern neurology.

In order to accord plants their due share of attention a few suggestions toward systematic botany and the means of determining species are given and particular attention is directed to habits, habitats, seasons of flowering and ripening seed, geographical range and economic importance of native forest trees.

This part of the course is intended to give the students a glimpse into systematic botany and forestry.

I should add in conclusion one other feature of the entire course. The æsthetic is an important factor in the study of living nature; and while I should be inclined to give dynamic relations precedence in determining selection of types, between two types of equal dynamic importance I should choose the more beautiful. And, furthermore, we constantly discover æsthetic elements in the ugliest of types; and when by the aid of the dynamic standpoint we gain an insight into adjustments with environment and harmony in nature, we reach a deeper plane of æsthetic relations even more vital to our philosophies of life than that which lies on the surface. Very little can be said about all this and the less said the better, so long as the student is brought into personal relation to the fact that nature is beautiful to the core. Haeckel's "Kunst Formen der Natur" is the text for this phase of the course.

Nothing is farther from my thought than to claim for the above course anything approaching perfection. In fact, one of my chief motives for submitting it to the public in this form is to ask for criticism and suggestion by any who may be struggling with the same problem. I may add that from three years' experience the course seems to meet the requirements of the case rather better than I had dared to hope. It has apparently enabled a number of my students to discover their bent and decide upon their life work. Many more, who are specializing in directions other than biology, bear ample testimony that the work has not died within them but has become one among the number of permanent and cherished interests. When a young man a year or two after taking the course comes to me and says: "I am coming to realize more and more what our study of biology really means. Walking used to be rather dull business with me, but now it is more interesting than a novel. Every bird and tree and moss and fern and insect, frog, toad, fish or even snake has something new and interesting to tell me," may we not feel that we are, at least, approaching a solution to our problem?

I cannot close without again acknowledging my indebtedness to Huxley; and when he writes: (Evolution and Ethics, p. 50, 1893.) "Thus the most obvious attribute of the cosmos is its impermanence. It assumes the aspect not so much of a permanent entity as of a changeful process, in which naught endures save the flow of energy and the rational order which pervades it"—is he not clearly pointing toward dynamic biology? And again he says: "I cannot but think that there is room for all of us to work in helping to bridge over the great abyss of ignorance which lies at our feet."

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